

The Tokyo Metropolitan Area Convection Study (TOMACS): Background and design of the observational test bed for extreme weather in an urban area

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The Tokyo Metropolitan Area Convection Study (TOMACS), supported by the Japan Science and Technology Agency, is a major new program of meteorological observations, modeling and social experiments in urban area. The aim of this study is to improve to understand the process and mechanism of extreme weather that affects social activities in an urban area. The urban areas are considered to be more susceptible to extreme weather than are the rural areas because social infrastructures in urban areas including transportation and communication networks and paved streets are vulnerable to severe weather. Once such a phenomena occurs, it would produce appreciable damages such as breakdowns of the highly developed networks, submersion, and loss of lives.

The TOMACS employs dense observation networks of innovative observation facilities for 5 years starting from 2010 in the Tokyo metropolitan area as a test bed to mitigate damages and/or loss of lives associated with severe weather. Observation facilities include C-band research polarimetric radar, C-band operational Doppler radars, X-band Polarimetric radar network (X-NET), Doppler lidars, Ku-band Polarimetric radar, unmanned air vehicle, dense GPS and surface observation networks. More than 25 organizations and over 100 people are participating in this study to operate and support the facilities. The data are used for the elucidation of mechanisms of severe weather events, the data assimilation of mesoscale models, and weather warnings transferred to local specified people as a social experiment. This paper introduces the background of the TOMACS, the design of the study, and some observation facilities including preliminary results.

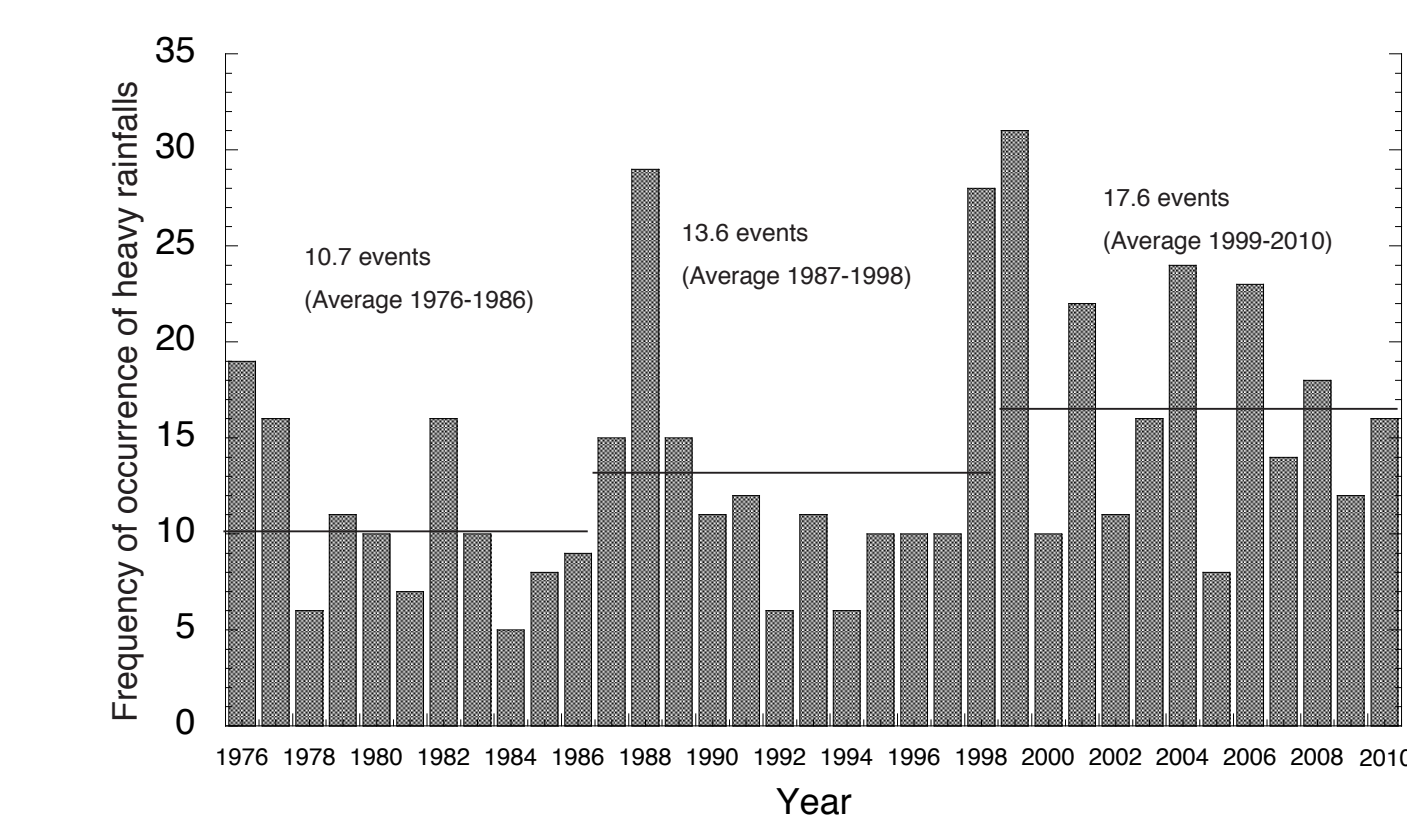


Figure 1. Time series of the frequency of occurrence of heavy rainfalls (>80mm/h) per 1000 surface observation stations from 1976 to 2010 in Japan. The lines indicate averaged frequencies of the occurrence over about 12 years in three periods (1976-1986, 1987-1998 and 1999-2010). Modified from JMA (2011).

Social Experiments on Resilient Cities for Extreme Weather

MEXT-JST Special Coordination Funds for Promoting Science and Technology, FY2010-2014

Many types of deep convection are generated in the warm season in the Tokyo Metropolitan area

Subject 2: Early Detection and Prediction System

[Engineering]

Developments collaborating with end users

(1) Extreme weather nowcasting methods

(2) Development of test-beds of nowcasting systems

(3) Extreme weather database

Monitoring/Nowcasting System

Hazard Map

Nowcasting

Subject 1: Field Experiments

[Meteorology]

To obtain new insight on mechanisms of extreme weather

(1) Development of new technologies

(2) Field campaign in the Tokyo area

(3) Statistical analysis

New observation facilities

Subject 3: Social Experiments

[Sociology]

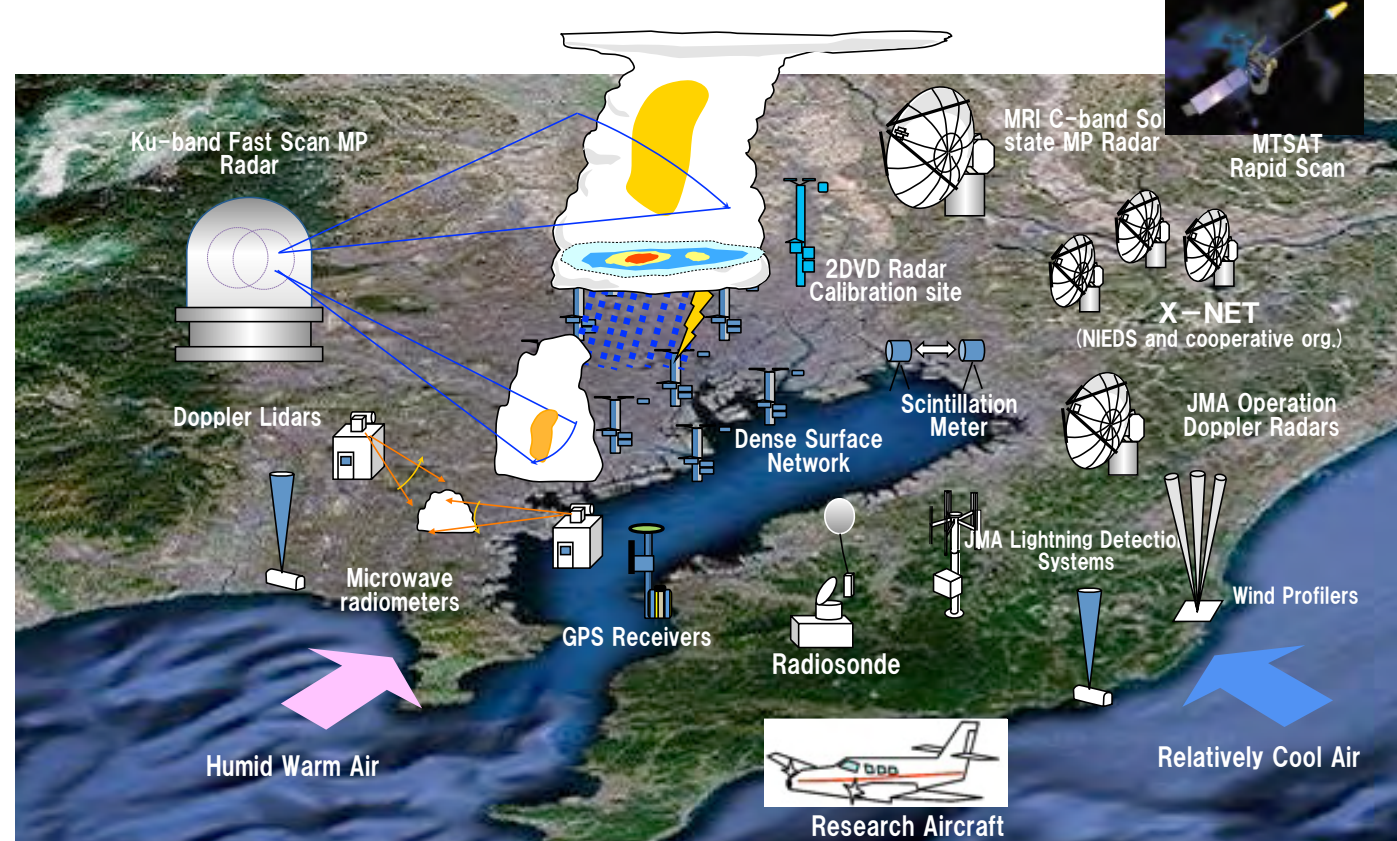
Evaluation and adaption the developed nowcasting system

(1) Social experiments in rescue services, risk management, infrastructure and education

(2) Recommendations for extreme weather resilient cities

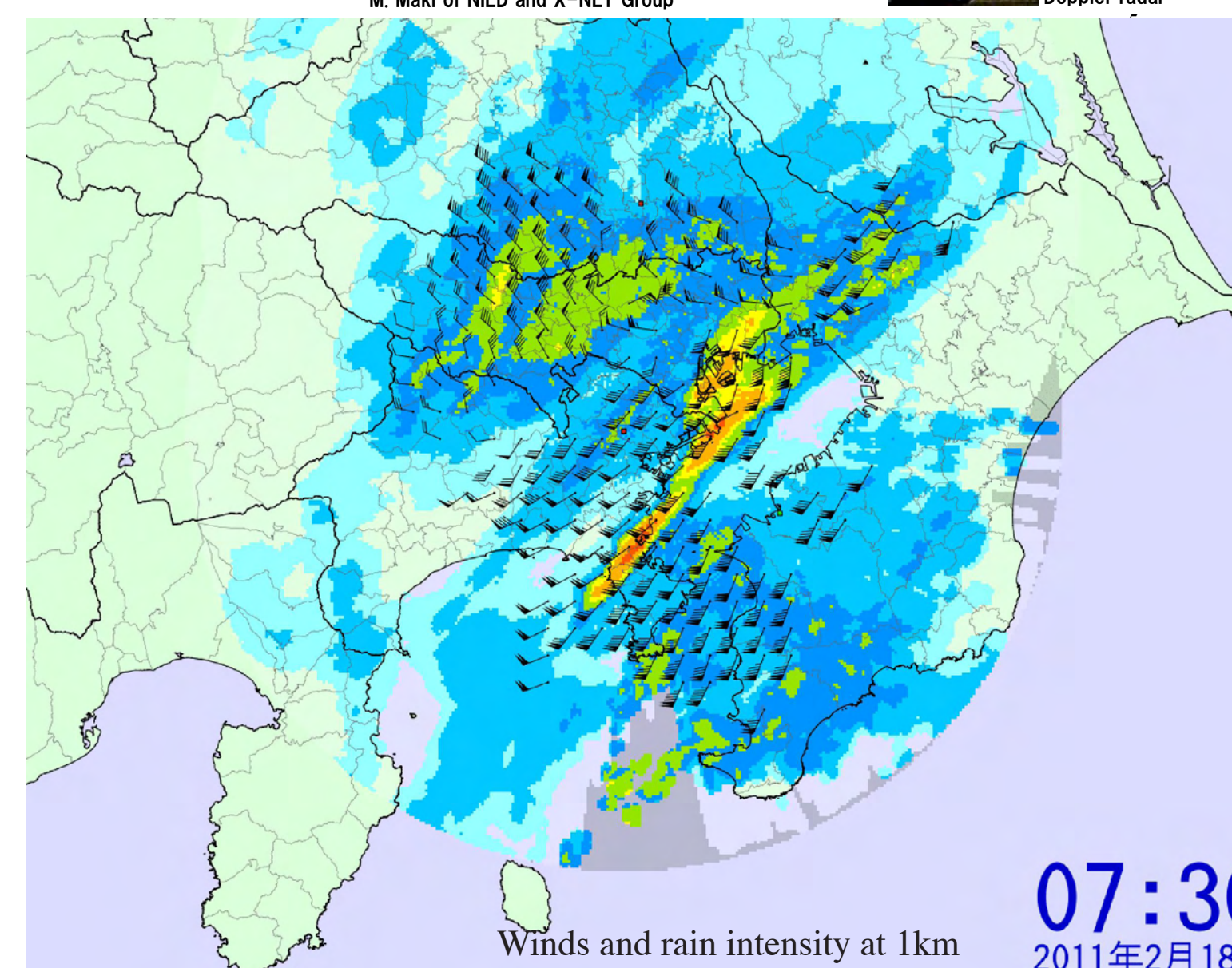
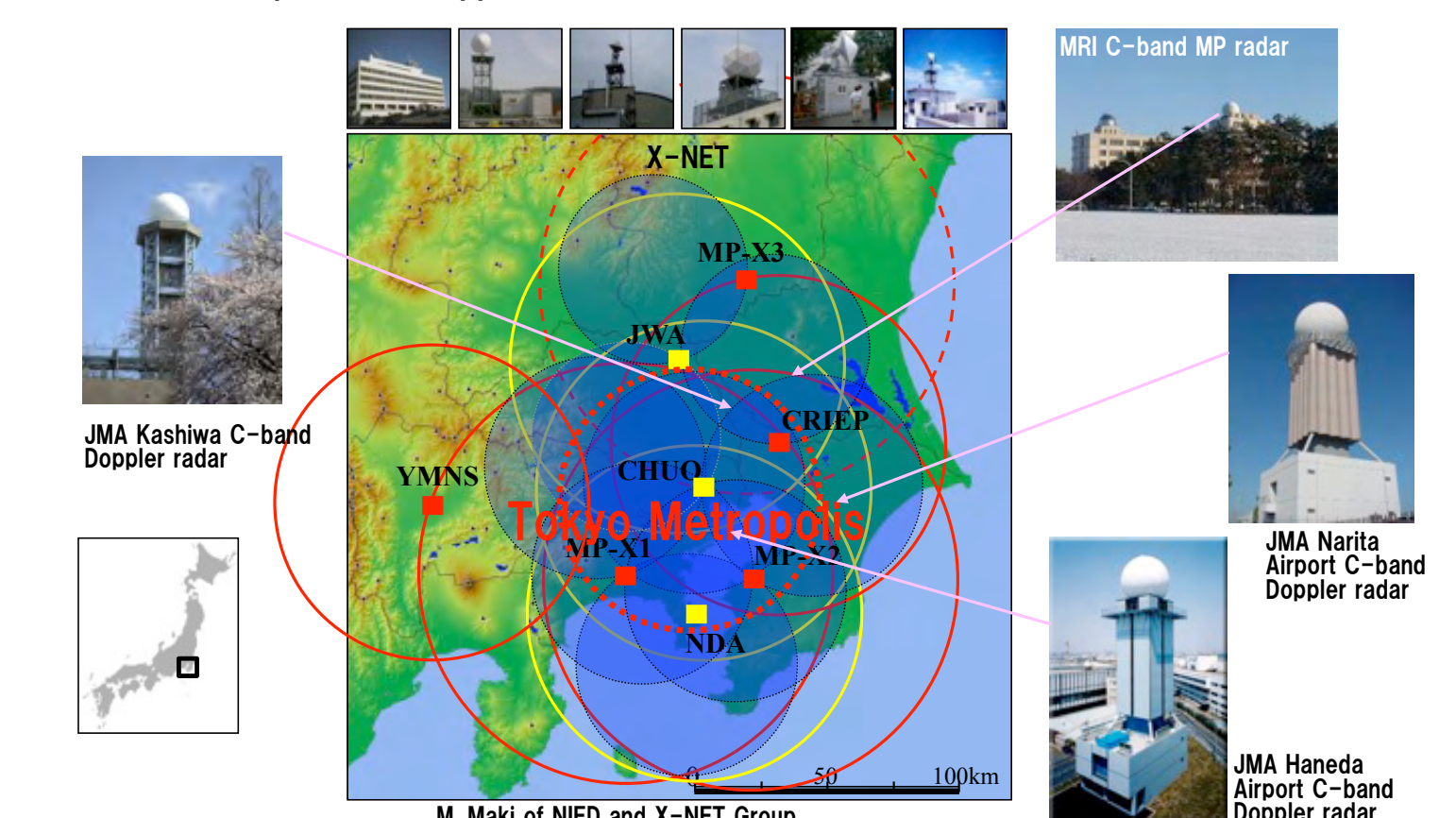
High density field campaign

TOMACS (Tokyo Metropolitan Area Convection Study) with a dense observation network by MRI, NIED and 12 research groups in the summers of 2011-2013, as testbed for deep convection.



14 Doppler Radars

Research/operation weather radars concentrate in the Tokyo Metropolitan Area: X-NET (5 X-band MP radars and 3 Doppler radars), two X-band MP radars of River Bureau, MRI C-band MP radar and 3 JMA C-band operational Doppler radars.

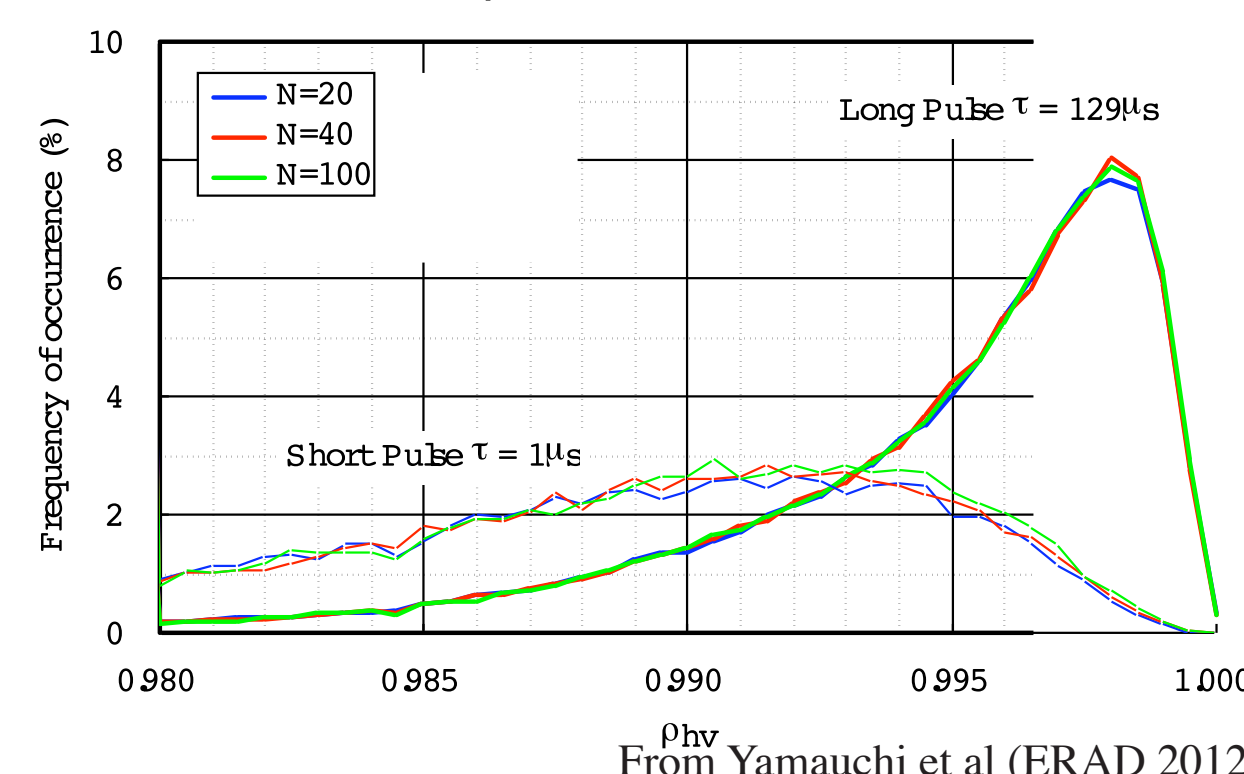


Specifications

	MRI C-band polarimetric Doppler weather radar equipped with solid state transmitters	Conventional Doppler weather radar (The former MRI C-band Doppler weather radar)
Transmitting frequency	5.37GHz (C-band)	5.26GHz (C-band)
Transmitter	Gallium / Arsenic Power FET	Magnetron
Peak transmitting power	Horizontal transmitter 3.5kW Vertical transmitter 3.5kW	250kW
Pulse width	1 - 350μsec (variable)	1, 2.5μsec
Pulse repetition frequency	260 - 2000Hz	260 - 940Hz
Antenna	Parabola, Diameter 4m	Parabola, Diameter 4m
Antenna speed	Max. 10 rpm	Max. 5 rpm
Reflectivity (Z _h)	Doppler velocity (V)	Doppler velocity (V)
Velocity width (W)	Differential reflectivity (Z _{dr})	Velocity width (W)
Output data	Differential coefficient (Z _{dr})	
	Differential phase (Z _{dr})	
(Manufacture)	TOSHIBA	MITSUBISHI

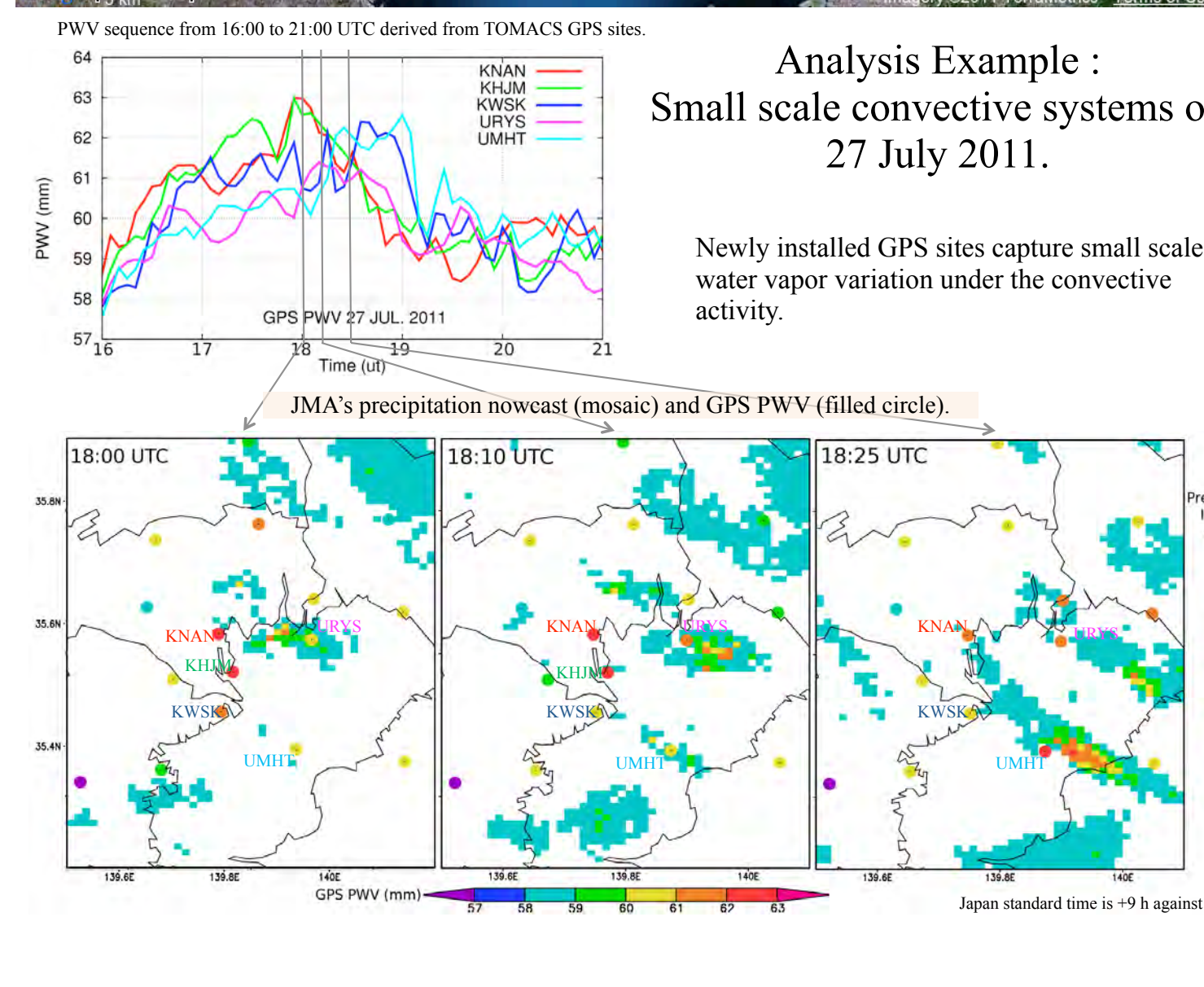
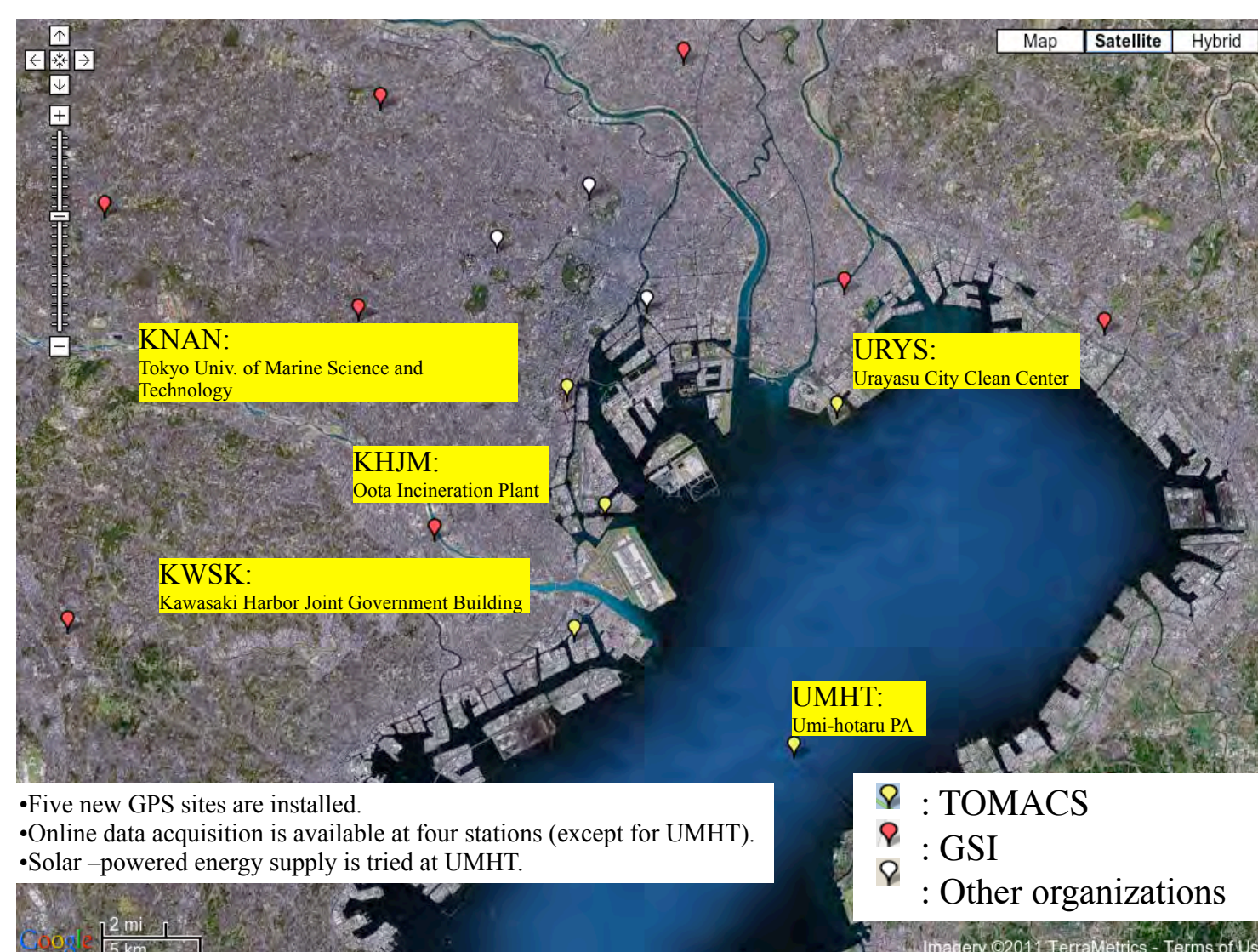
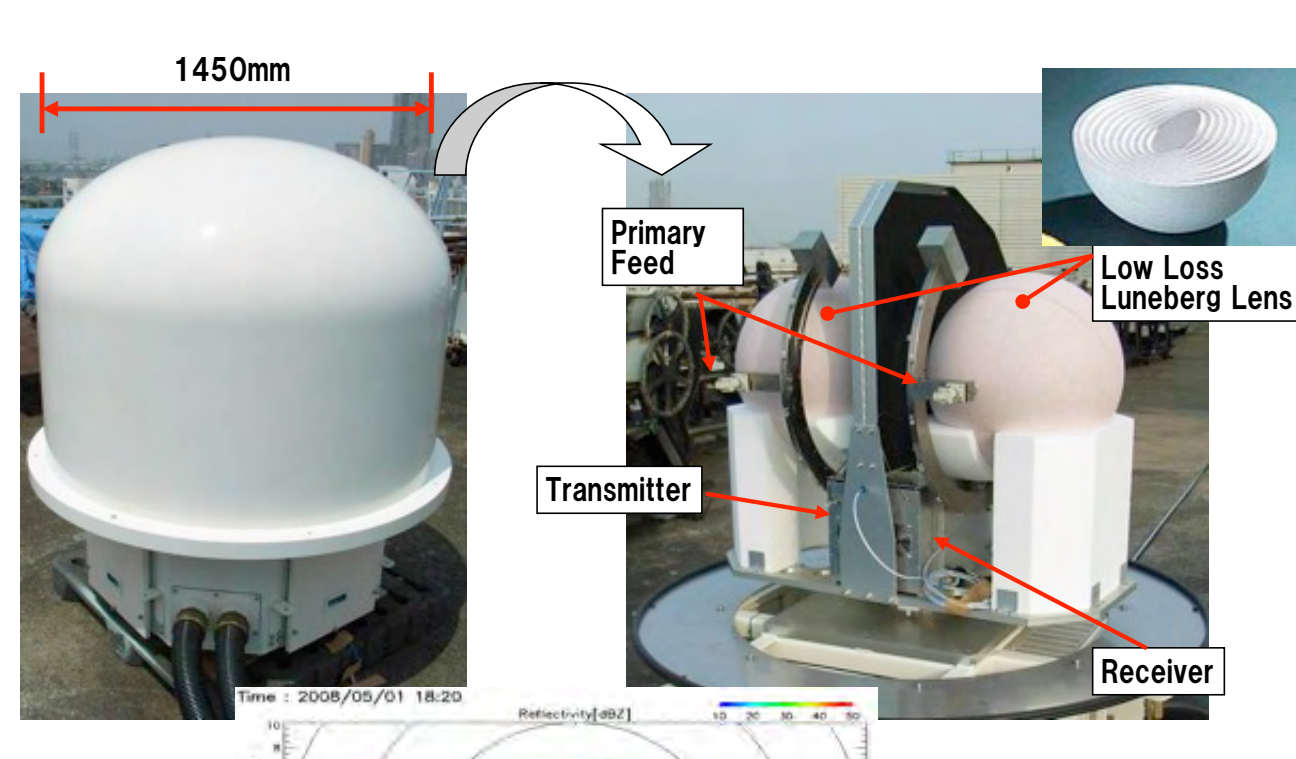
Distribution of ρ_{hv} in Rain (SNR>20)

- Independent of sample (hit) number N.
- Peak values are 0.998 for long pulse observation, 0.992 for short pulse observation.



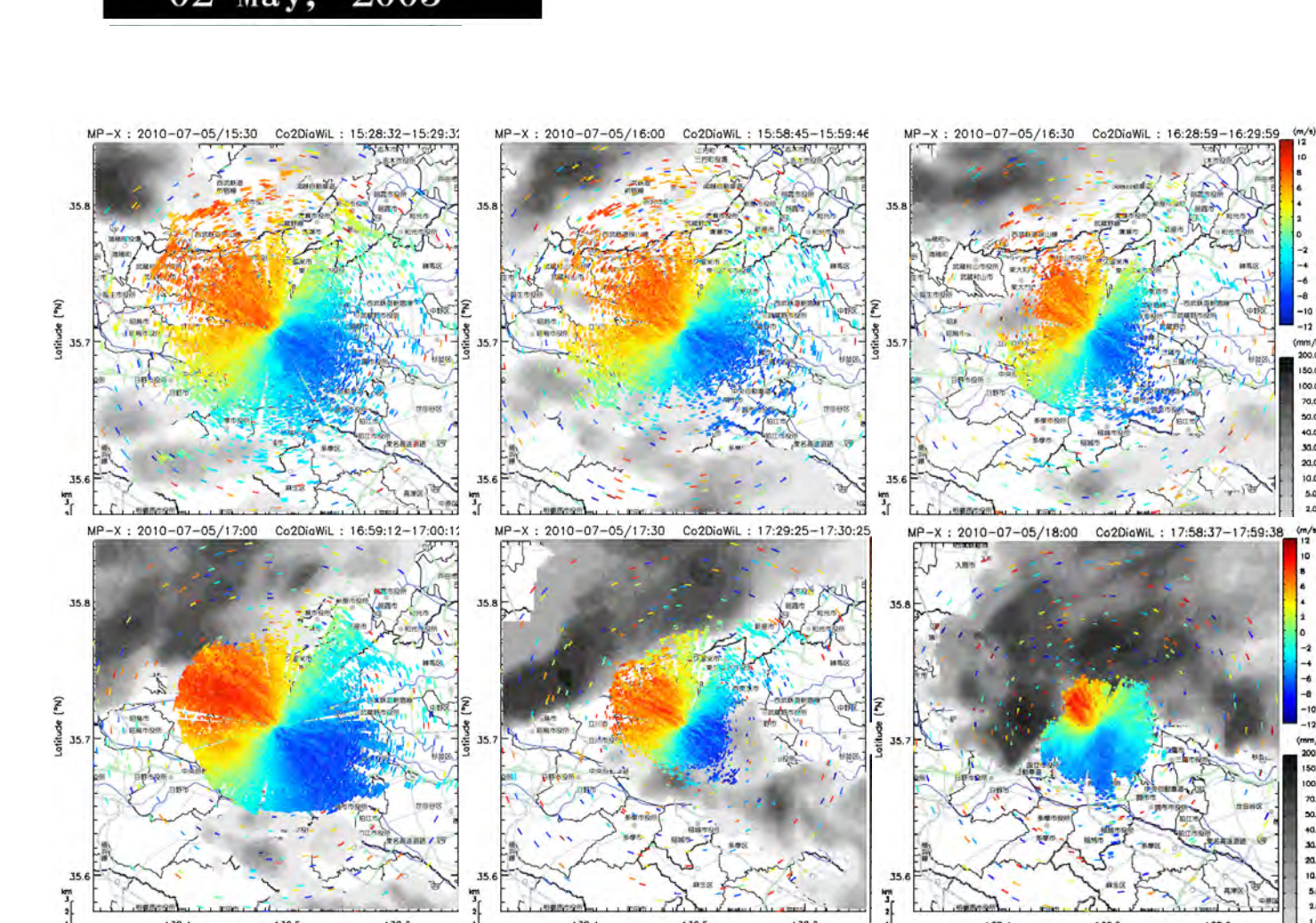
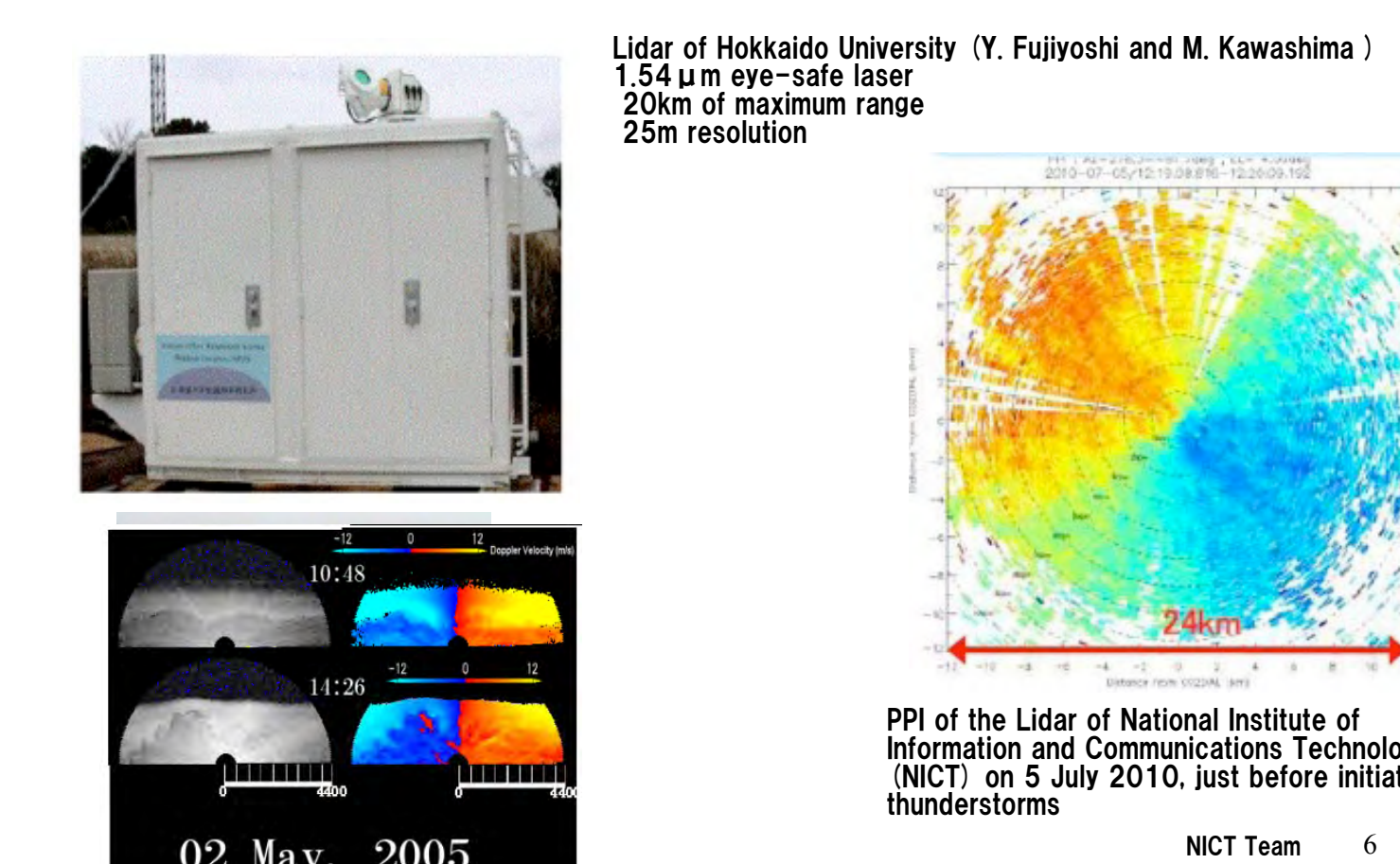
Ku band fast scan broadband radar (15.75GHz)

The Ku-band FM-Chirp fast scan MP radar developed by the Osaka University and Sumitomo Electric Industries is used to observe very high-resolution structure of thunderstorms. A full volume scan is made by 1 minute intervals, and reflectivity, Doppler velocity and polarimetric parameters are obtained at 10m intervals.

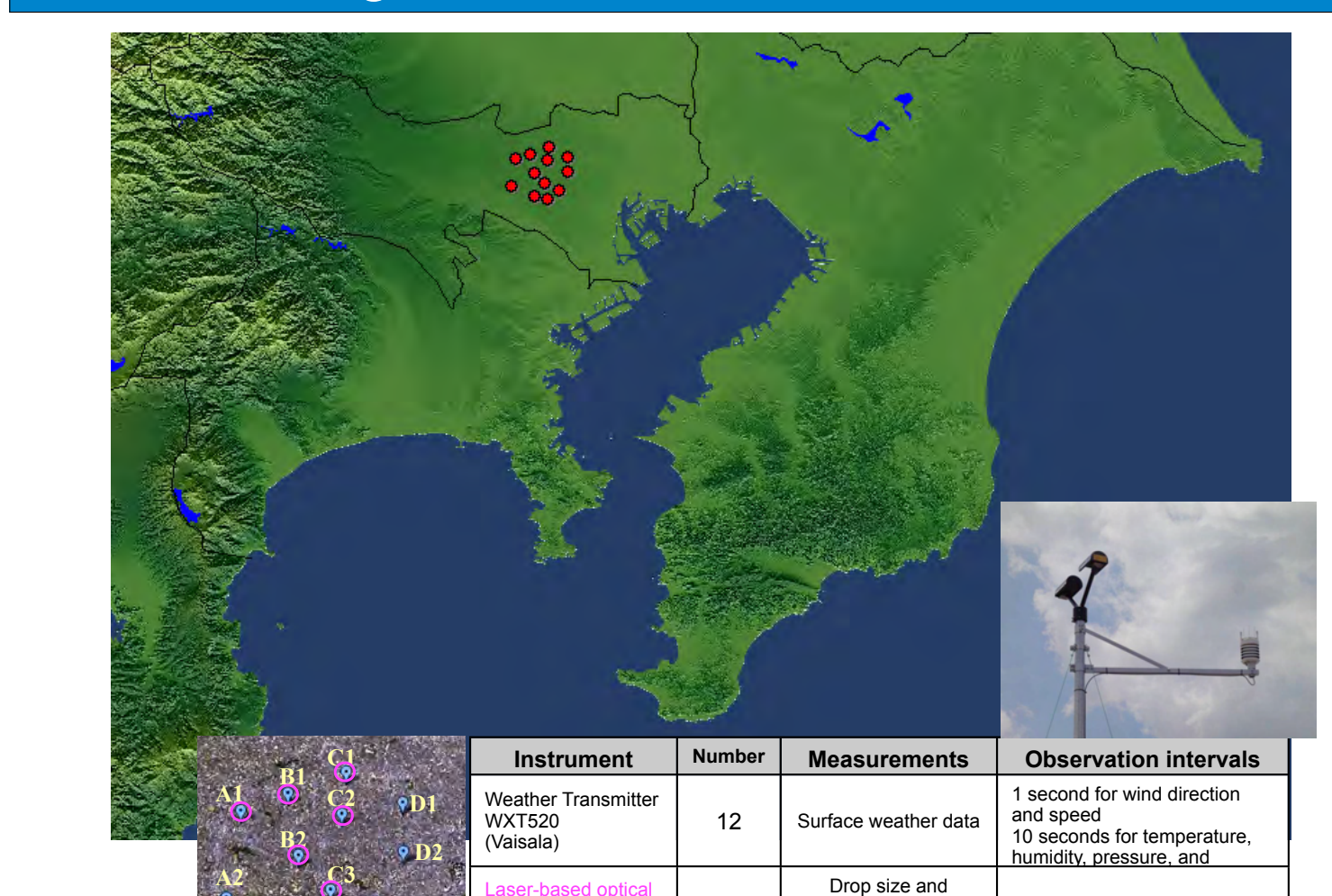


6 Doppler Lidars and a microwave radiometer

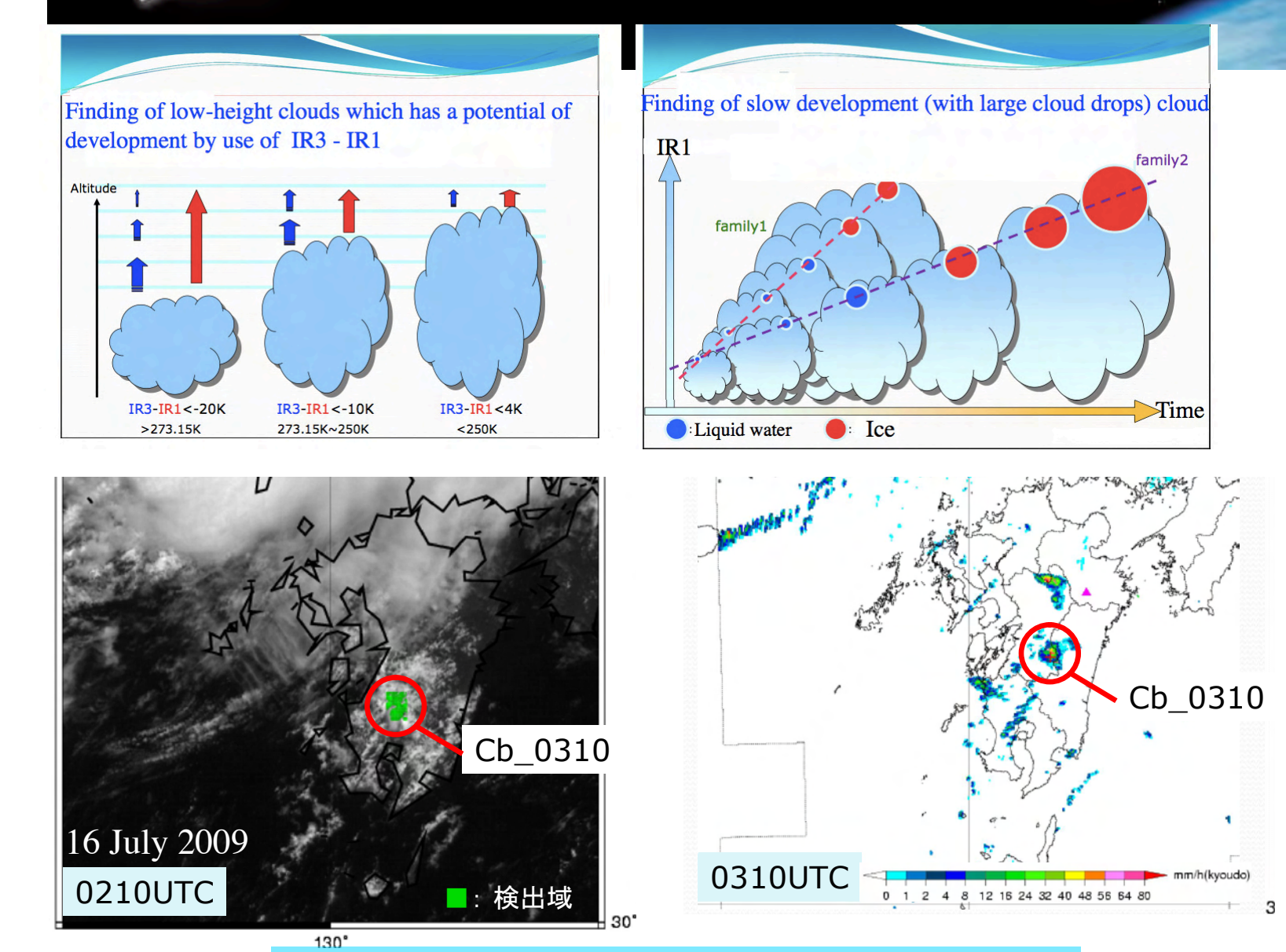
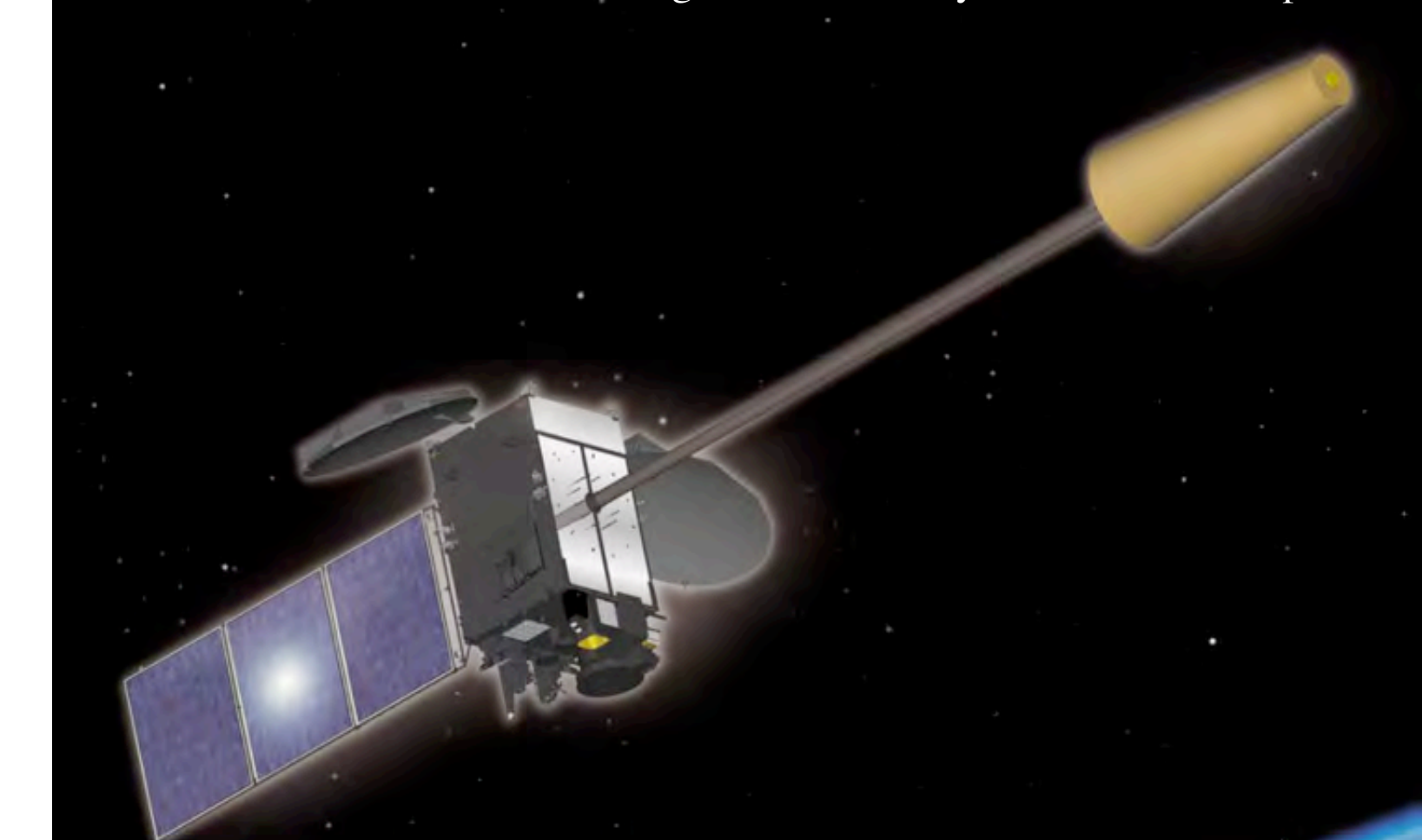
Two research Doppler lidars are operated in the experiment in addition to four JMA operational Doppler lidars in the Haneda and Narita airports. To observe the initiation of convection and behaviors of sea breeze fronts.



High-resolution AWS network

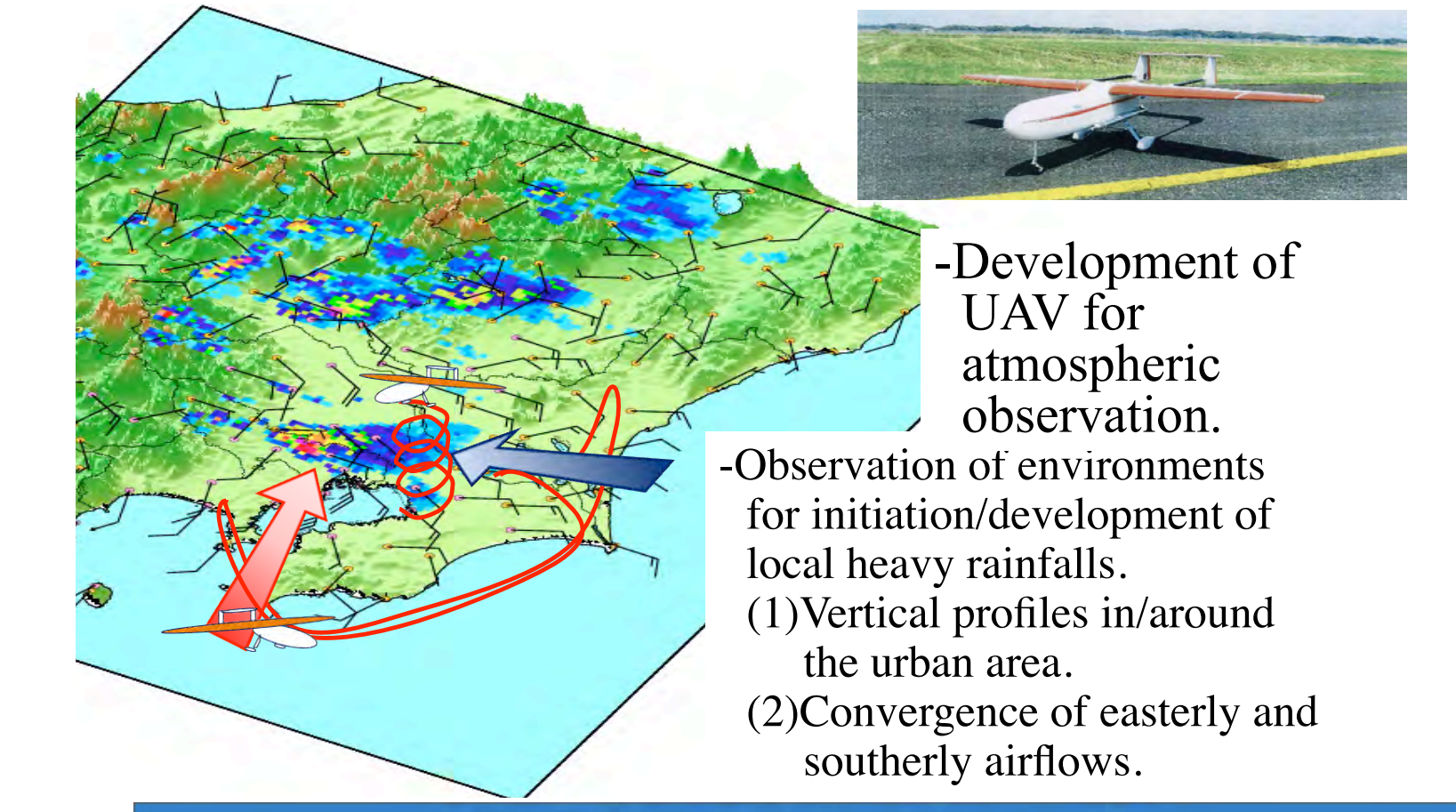


Rapid scan by the JMA Geostationary Satellite (MTSTAT) has started from 2010 summer with visible and IR images taken in every 5 minutes over Japan



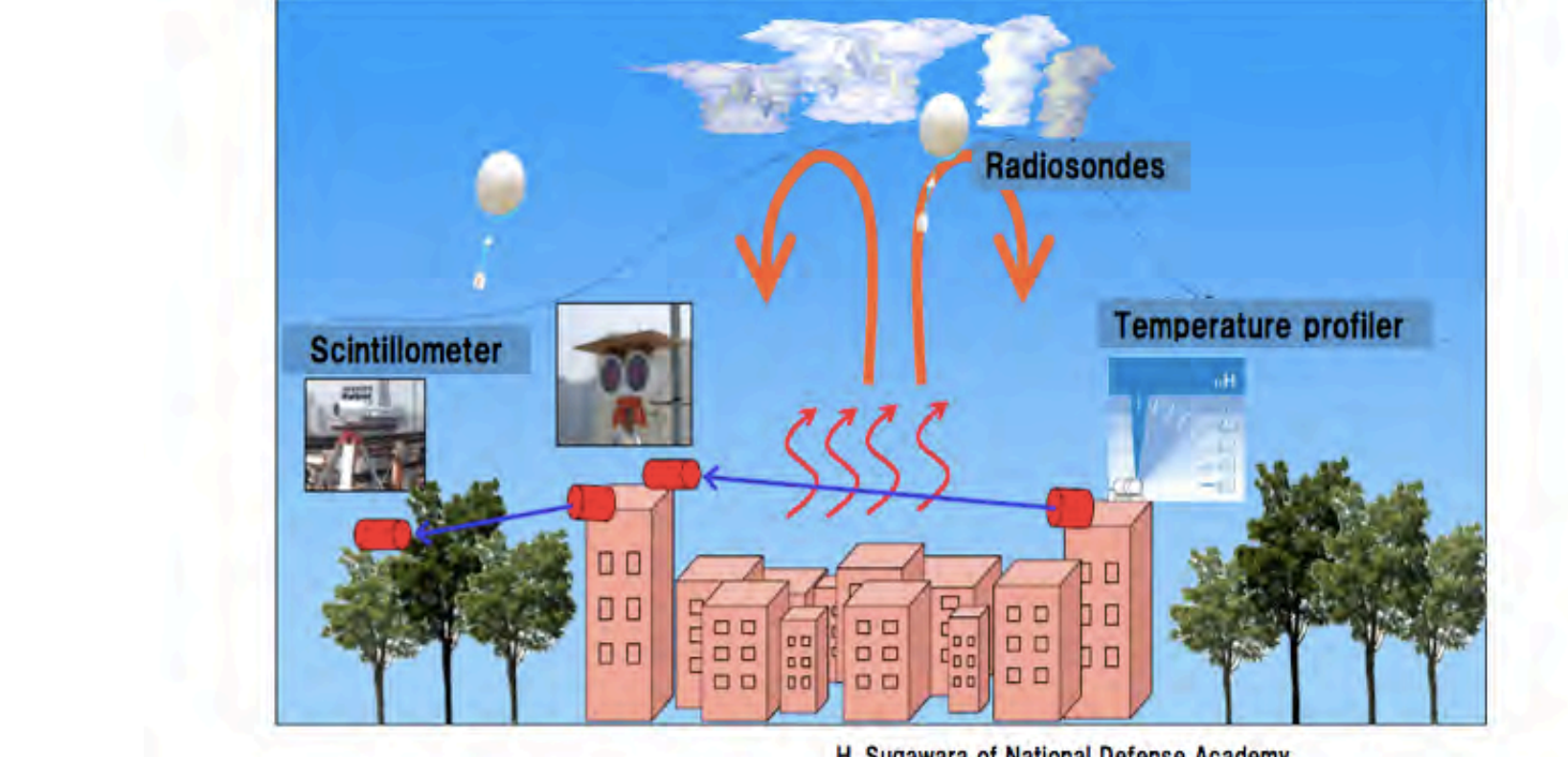
TOMACS: UAV airplane

To capture atmospheric environment for heavy rainfall/urban PBL structure

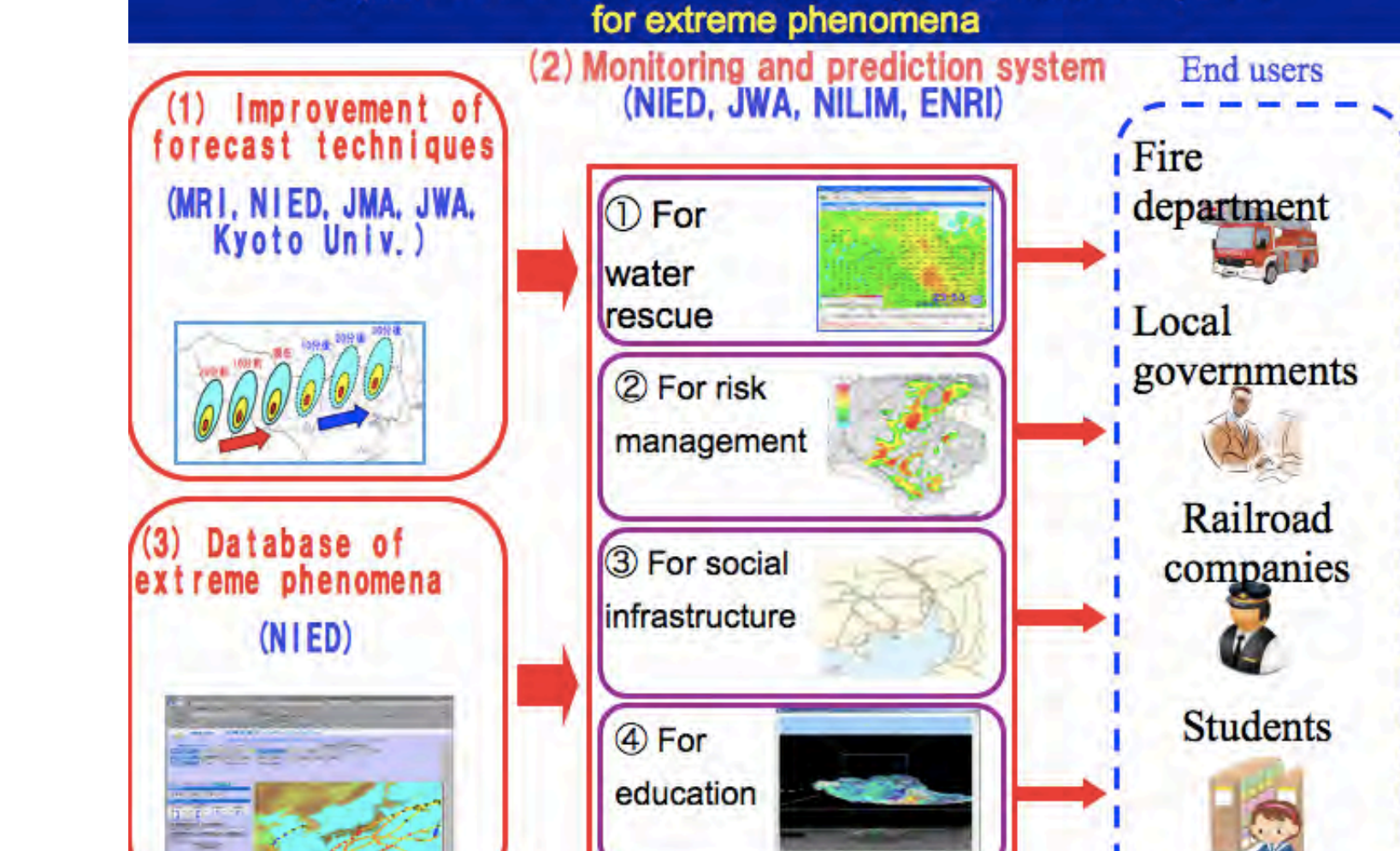


Boundary layer observation

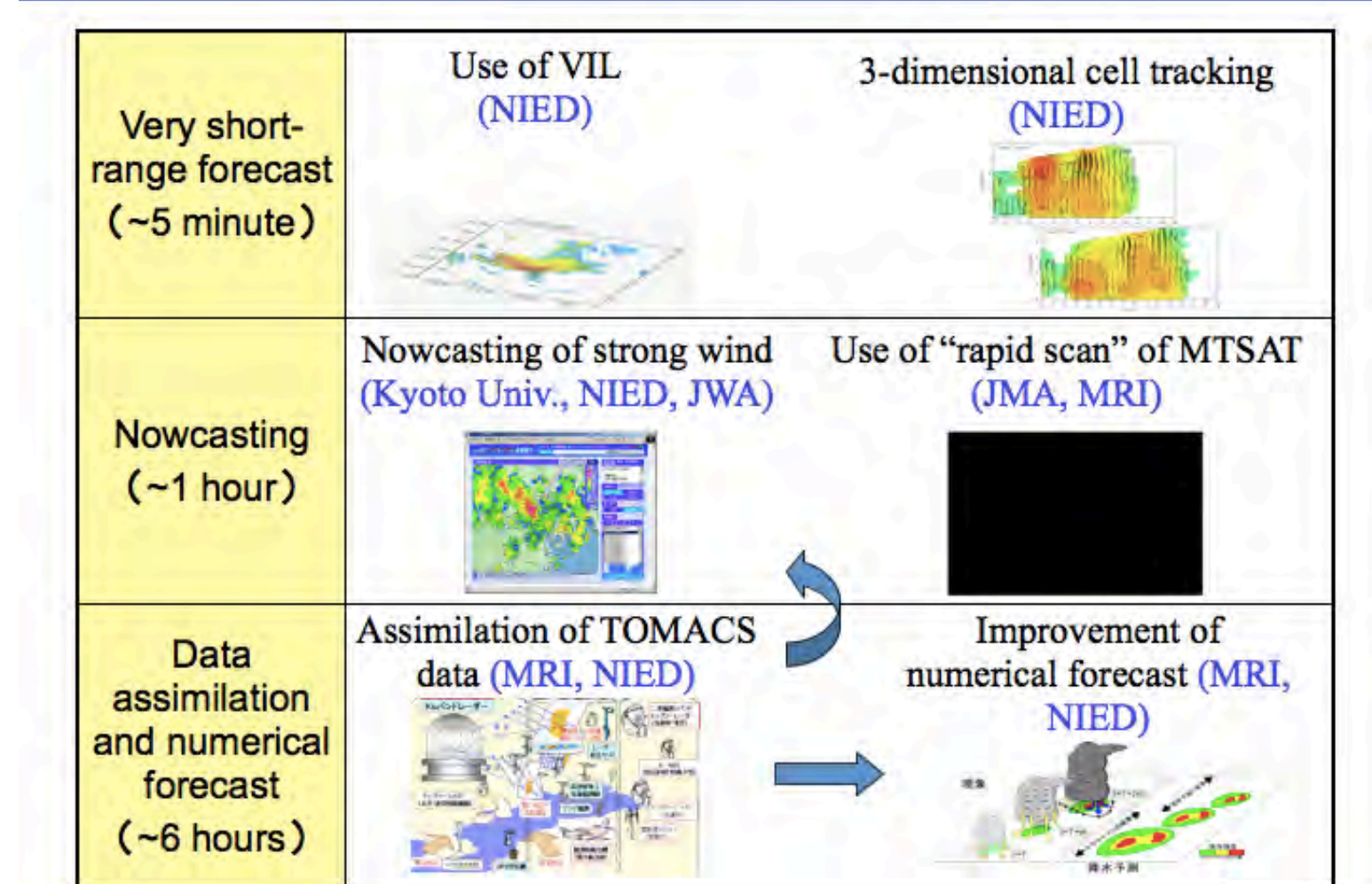
Relationship between sensible heat flux from the surface and the initiation of convection will be studied using scintillation meters, radiosondes, temperature profilers, wind profilers.



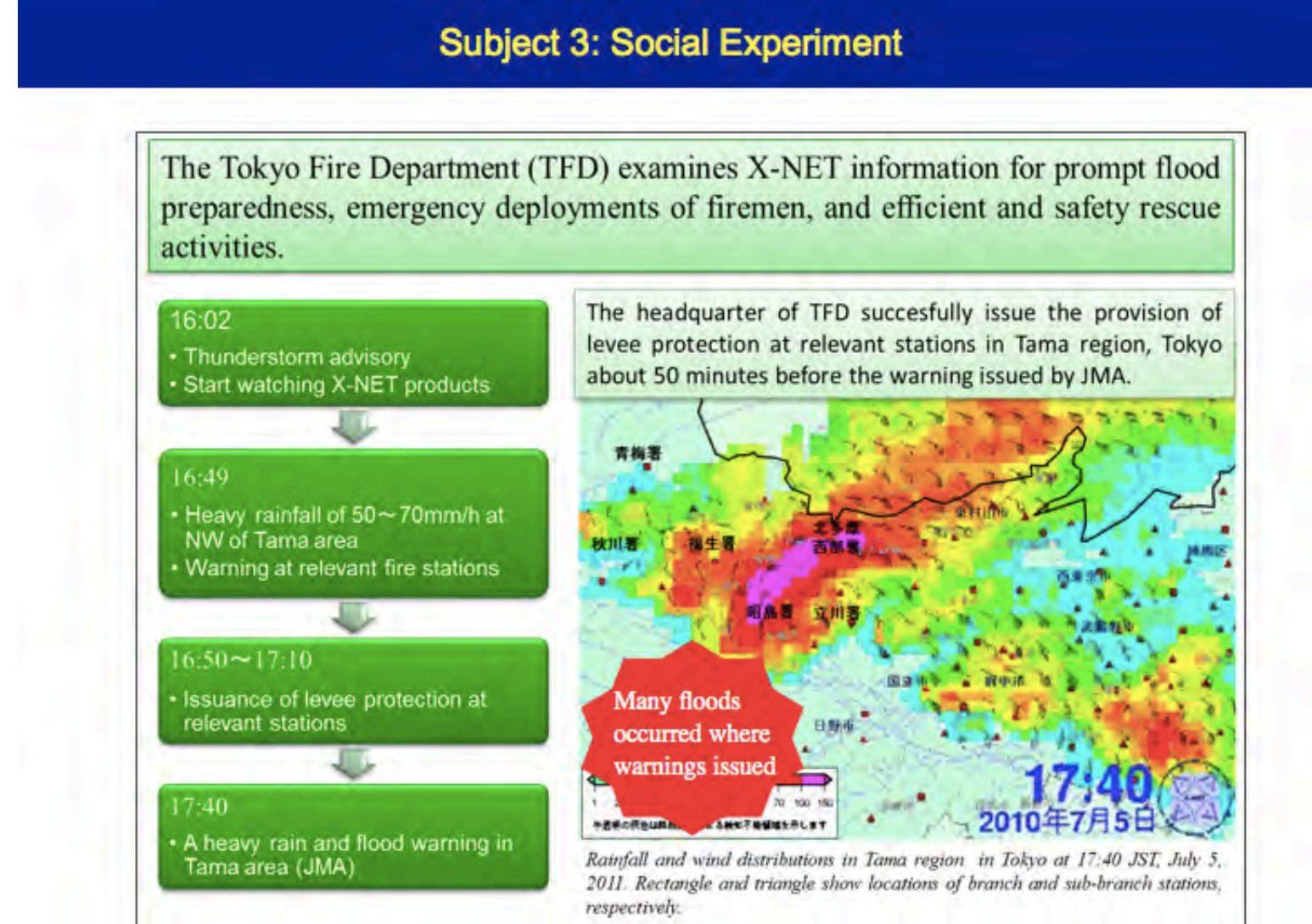
Subject 2: Development of monitoring and prediction system for extreme phenomena



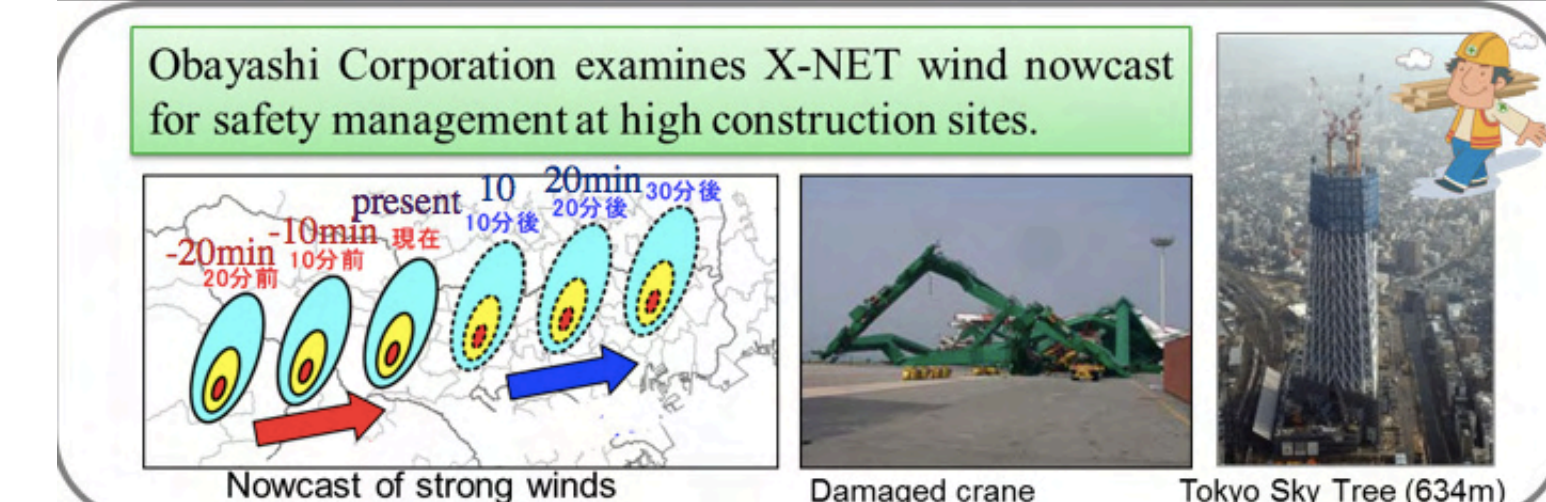
(1) Improvement of forecast techniques



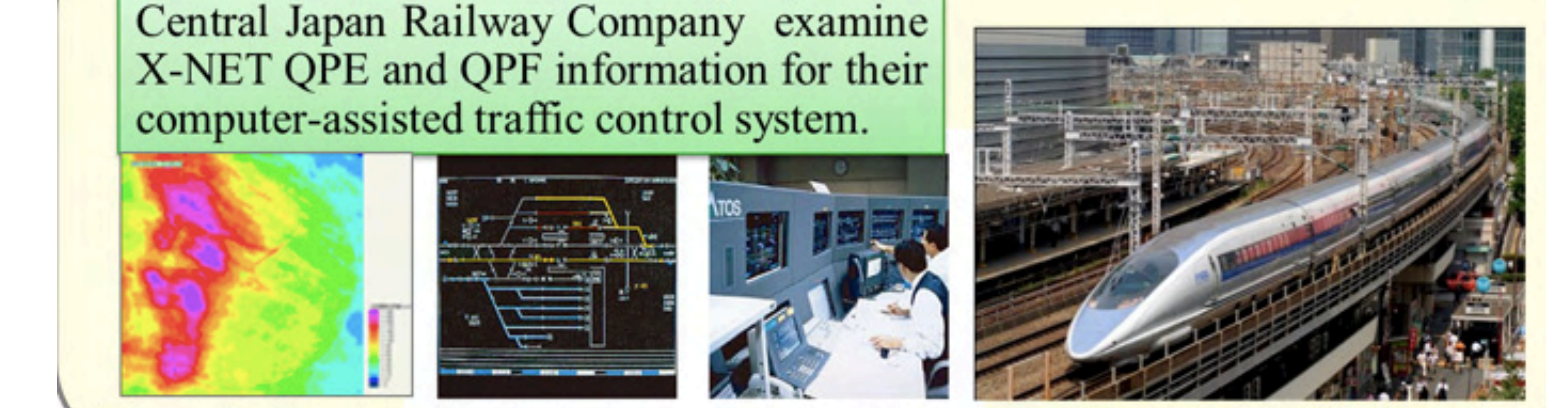
Subject 3: Social Experiment



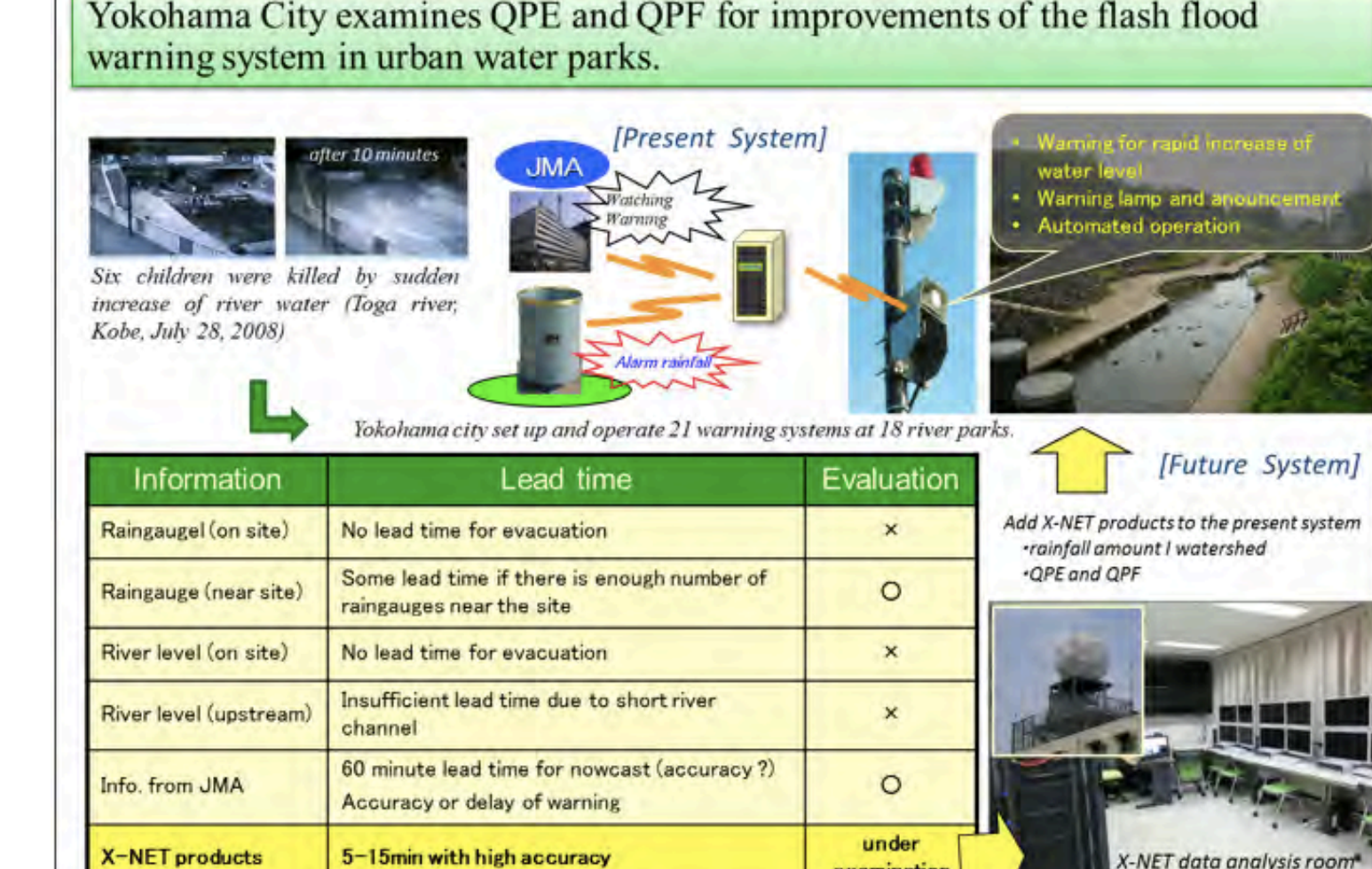
Obayashi Corporation examines X-NET wind nowcast for safety management at high construction sites.



East Japan Railway Company and Central Japan Railway Company examine X-NET QPE and QPF information for their computer-assisted traffic control system.



Yokohama City examines QPE and QPF for improvements of the flash flood warning system in urban water parks.



Summary

Social Experiments on Extreme Weather Resilient Cities in Tokyo Metropolitan area have been started from the last summer

